Claims

1: A device comprising a mechanical component, the mechanical component being formed of a hyperelastic material having a crystalline phase change transition temperature.

2. A device as in claim 1 in which the hyperelastic material has an austenite crystalline phase when at a temperature above the phase change transition temperature, the material being in a martensite crystalline phase when at a temperature below the phase change transition temperature.

3. A device as in claim 1 in which the hyperelastic material has an austenite crystalline phase when below the material's phase change transition stress level, the material being in a martensite crystalline phase when at a mechanical stress above the material's phase change transition stress level.

4. A device as in claim 1 in which the hyperelastic material is a single crystal of CuAlNi alloy.

5. A device as in claim 4 in which the hyperelastic material is CuAlNi alloy and its crystallographic direction <100> of the crystal is aligned with the longitudinal axis of the guidewire.

6. A device as in claim 1 in which the hyperelastic material comprises copper, aluminum, and a metal selected from the group consisting of Ni, Fe, Co, and Mn.

7. A device as in claim 1 for use in medical procedures on a body of a human or other animal, the mechanical component comprises a guidewire which is sized for insertion into the body.

8. A device as in claim 7 in which the metallic components of the alloy are sufficiently proportioned to provide properties of flexibility and torqueability enabling optimum movement of the guidewire through the body.

9. A device as in claim 7 and further comprising a biocompatible coating formed about the guidewire, the coating being comprised of a material selected from the group consisting of gold, a biocompatible plastic, and a biocompatible polymer.

10. A device as in claim 7 in which the guidewire has one portion comprised of a hyperelastic SMA material having a phase change transition temperature no greater than the temperature of the body whereby the one portion when in the body is heated to the austenite phase and has hyperelastic properties.

11. A device as in claim 7 in which the guidewire has an other portion comprised of a hyperelastic material having a phase change transition temperature greater than the body temperature whereby the other portion when in the body is in a martensite phase and has malleable properties.

12. A device as in claim 7 in which the guidewire has a given diameter, and the hyperelastic material when in the austenite phase has a recoverable distortion sufficient to enable the guidewire responsive to a stress being deformed by bending through an arc as much as 9 percent of the guidewire diameter divided by the arc diameter and further enabling the guidewire when unstressed to recover all of the deformation.

13. A device as in claim 7 in which the guidewire comprises one portion having a given diameter and an other portion, the other portion having a diameter that is less than the given diameter sufficient to enable the other portion responsive to a given stress to flex through a greater degree than when the one portion is flexed responsive to the given stress.

14. A device as in claim 7 in which the guidewire comprises one portion having a given diameter and an other portion, the other portion having a composition different from the first portion sufficient to enable the other portion responsive to a given stress to flex through a greater degree than when the one portion is flexed responsive to the given stress.

15. A device as in claim 7 in which the device further comprises a catheter having a hollow sleeve, and the guidewire is fitted for axial movement within the sleeve.

16. A method of fabricating a single crystal shape memory alloy having hyperelastic properties, the method comprising the steps of: providing a molten melt of a copper aluminum based alloy, pulling a column of the alloy from the melt at a predetermined pulling rate, applying a predetermined hydrostatic pressure on the column and heating the column to a predetermined temperature, the predetermined pulling rate, hydrostatic pressure and temperature being sufficient to crystallize the alloy in the column into a single crystal, and quenching the single crystal.

17. A method as in claim 16 in which the predetermined temperature is at least about 1000 degrees Celsius, and the quenching step is carried out by quenching from about 850 degrees Celsius.

18. A method as in claim 16 in which the compositions of the alloy are substantially 80 percent Cu, 15 percent Al and 5 percent of a metal selected from the group consisting of Ni, Co, Mn, Fe.

19. A method as in claim 16 in which the quenching step is carried out by quenching the alloy in salt water.

20. A method as in claim 16 in which the single crystal shape memory alloy

is for use as a guidewire in medical procedures, the step of pulling the column is sufficient to form a length of wire, and grinding the surface of the wire to a diameter in the range of from 0.012 inches to 0.039 inches.

21. A method as in claim 16 in which the grinding step is carried out by centerless grinding of the surface.

22. A method as in claim 20 and further comprising the step of electropolishing the wire to a smoothness of less than 0.0001 inches.

23. A method as in claim 20 and further comprising the step of coating the surface of the wire with a material selected from the group consisting of gold, a biocompatible plastic, and a biocompatible polymer.

24. A method as in claim 20 and further comprising the step of coating the surface of the wire with a lubricant.

25. A method as in claim 20 and further comprising the step of etching a portion of the surface of the wire in a mixture of hydrofluoric acid and nitric acid in amounts which reduce the diameter of the wire sufficient to increase the flexibility of the portion.

26. A method as in claim 16 in which the step of pulling the column is carried out by pulling a hollow cross-sectional elongated shaped column.

27. A method as in claim 20 in which the column has an outer layer comprised of CuAlNi polycrystal, and further comprising the step of removing the polycrystal in the outer layer.

28. A device as in claim 1 for use as a flexure in which the mechanical component comprises an elongated strip having an arcuate cross-section lateral of the strip's long axis, the strip having a given width and a

thickness which is sufficiently thinner than the given width to enable the strip to buckle transversely of the long axis responsive to a first load while further enabling the strip to have a rigidity which resists the buckling responsive to a second load which is less than the first load.

29. A device as in claim 28 which further comprises a deployable structure, the deployable structure comprising first and second struts, and the flexure interconnects the first and second struts for flexure between a stowed orientation in which the struts are folded toward each other and a deployed orientation in which the struts extend substantially along a common axis.

30. A device as in claim 29 in which the deployable structure comprises a boom.

31. A device as in claim 29 in which the deployable structure comprises an antenna.

32. A device as in claim 29 in which the deployable structure comprises a solar panel.

33. A device as in claim 1 for use as an actuator, the device further comprising a first element, an actuation element which is mounted for movement relative to the first element between a stowed position and a deployed position, a bias element which applies a restoring force urging the actuation element toward the stowed position, and the mechanical component is in the form of a spring which applies a force of a given magnitude urging the actuation element toward the deployed position responsive to the hyperelastic material being in the austenite crystalline phase, and the mechanical component further applying a force less than the restoring force responsive to the hyperelastic material being in the martensite crystalline phase.

34. A device as in claim 1 for use as a combination heat pipe and flexure, the device comprising first and second elements, the mechanical component comprises a tubular joint having a hollow interior for constraining a fluid flow, the joint having a first end connected with the first element and a second end connected with the second element, the elements being pivotal about the axis between a deployed orientation responsive to the hyperelastic material being in the austenite crystalline phase and a stowed orientation responsive to the hyperelastic material being in the martensite crystalline phase, and means for directing the flow of a fluid between the first and second ends of the joint.

35. A device as in claim 1 for use as an electrical switch to open and close a circuit path, the device further comprising a first contact which is connected with the circuit, the mechanical component further comprising a second contact, the second contact being positioned for movement toward a position spaced from the first contact to open the circuit responsive to the hyperelastic material being in the martensite crystalline phase, and the second contact being positioned for movement toward an other position in contact with the first contact to close the circuit responsive to the hyperelastic material being in the austenite crystalline phase.

36. A device as in claim 1 for use in applying a substantially constant force throughout a range of movement between first and second structures, the mechanical component further comprising a force-applying element having a first portion carried on the first structure and a second portion carried on the second structure, the force-applying element when the hyperelastic material is in the austenite crystalline phase being enabled to distort through a range of movement while applying a substantially constant force between the first and second structures.

37. A device as in claim 36 in which the force-applying element comprises a torsion spring.

38. A device as in claim 36 in which the force-applying element comprises a compression spring.

39. A device as in claim 36 in which the force-applying element comprises a tension spring.

40. A device as in claim 36 in which the force-applying element comprises a leaf spring.

41. A device as in claim 1 for use as a collapsible tube, the device further comprising a hollow tube having a first portion axially carried with a second portion, the second portion being comprised of the hyperelastic material, the second portion being shaped to expand outwardly to a deployed configuration having a given diameter responsive to the hyperelastic material being in the austenite crystalline phase, the second portion collapsing inwardly to a diameter smaller than the given diameter responsive to the hyperelastic material being in the martensite crystalline phase.

42. A device as in claim 41 in which the shape of the second portion comprises a plurality of interconnected strips separated by openings.

43. A device as in claim 1 for use as a probe tip in closing an electrical circuit with a contact pad of a microelectronic circuit on an integrated circuit chip, the mechanical component further comprising a cantilever beam having a longitudinal axis with a proximal end and a distal end, the crystalline direction <100> of the crystal being parallel to the axis, the distal end being formed with a point which moves into contact with the pad for closing the circuit.

44. A device as in claim 1 for use in storing large amounts of mechanical energy in a relatively small volume, the mechanical component further comprising a washer having a frusto-conical wall centered about a longitudinal axis, the wall flaring out from an opening of a given diameter at one end to an opening of a diameter larger than the given diameter at an opposite end, the wall responsive to an applied force along the axis gradually flattening while the ends move toward each other and the hyperelastic material in the austenite crystalline phase applying a constant resisting force against the applied force while storing mechanical energy from the applied force.

45. A device as in claim 1 for use in a structure for storing mechanical energy responsive to an applied force and releasing the stored energy responsive to the applied force being removed, the mechanical component further comprising a spring having one end carried by the structure and an other end, the other end being positioned to yieldably move in one direction responsive to the applied force, the hyperelastic material applying a constant resisting force against the applied force while storing mechanical energy from the applied force, and the hyperelastic material responsive to removal of the applied force causing the other end to move in an other direction while releasing the stored energy.

46. A device as in claim 45 in which the structure is selected from the group consisting of a bicycle wheel with spokes, athletic footwear, skis, and exercise equipment.

47. A device as in claim 1 for use as a pointed instrument, probe or needle, the mechanical component further comprising an elongated shaft extending along a longitudinal axis and having a distal end with a tip that has a sharp point, the tip being comprised of the hyperelastic

material, the tip being enabled by the hyperelastic material in the austenite crystalline phase to bend away from the longitudinal axis through a large displacement responsive to a force externally applied on the tip, and the tip returning to the initial position responsive to removal of the force.

48. A device as in claim 1 in which the mechanical component comprises an implantable medical tool for use in a human body.

49. A device as in claim 48 in which the medical tool comprises a stent.